TRAUMATIC DIAPHRAGMATIC HERNIA: TRANSPLEURAL REPAIR*

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DISCUSSION *by Charles Eaton Phillips, M. D., Los Angeles; Emile Holman, M. D., San Francisco.*

IN this paper I shall discuss and report eight cases† of traumatic diaphragmatic hernia which I have operated upon since October, 1935, by the transpleural approach, with recovery.

Diaphragmatic hernia can be divided into two groups: (1) nontraumatic; (2) traumatic. The nontraumatic are subdivided into congenital and acquired. Hedblom, in an analysis of 378 operated cases, found that two-thirds were of traumatic origin; one-sixth congenital and one-sixth acquired.

With the increase of injuries resulting from automobile accidents, the incidence of traumatic rupture of the diaphragm has increased.

TRAUMATIC HERNIA

Traumatic hernia may result from direct or indirect injury. Direct injuries to the diaphragm resulting from penetrating wounds, such as stab or gunshot, impalements and punctures from fractured ribs, are often accompanied by injuries to the lungs, liver, stomach, spleen, and kidneys.

Instances are reported of the rupture of the diaphragm during labor, vomiting, heavy lifting, and having the lower chest and upper abdomen crushed while wrestling. Rupture of the diaphragm has occurred in divers jumping from great heights and landing on their abdomen, also in persons jumping from a window and landing on their feet.

Rupture of the diaphragm has resulted from severe crushing injuries to the chest, with or without fractures. Fractures of the transverse processes of the upper lumbar vertebrae may also be a contributing factor.

Weakening of the diaphragm has resulted from a stiff rubber tube improperly placed in draining an empyema, causing an erosion of the diaphragm and a weakness of the muscle. With a sudden increase in the intrathoracic pressure, a tear occurs and a hernia develops.

A complete repair of the tear in the diaphragm will take place, provided no viscus intervenes between the edges of the torn muscle.

It was noted in the eight cases that the tear was parallel to the muscle fibers, extending from the anterolateral attachment of the diaphragm to the region of the esophageal hiatus. It is quite possible that the tear began at the central tendon in the dome of the diaphragm and extended anteriorly and posteriorly.

PATHOLOGY

No hernial sac was found in any of the eight cases. The formation of a sac depends upon the size and location of the defect in the diaphragm, and the rapidity with which the abdominal viscera enter through the defect. It is not infrequently seen in puncture wounds of the diaphragm, which develop a herniation into the pleural cavity years after the injury.

When a defect in the diaphragm exists, the intra-abdominal pressure associated with the continuous suction action of the diaphragm gradually increases the amount of the abdominal viscera in the chest. The viscera found in the pleural cavity depends upon the size and location of the tear in the diaphragm, and the rapidity with which the viscera enters immediately after injury.

In none of the cases was there any fluid, or blood-clots in the pleural cavity, and no adhesion between the lung and abdominal viscera. In two cases the lower lobe of the lung was adherent to the anterolateral chest wall by a cord-like bands. In all cases the lower lobe was more or less atelectatic; in one case the upper lobe was also partially airless. The lung was completely reëxpanded in all cases, without any ill effects from the reëxpansion.

SYMPTOMS

A paucity of clearly defined symptoms referable to the thorax and abdomen is characteristic in traumatic rupture of the diaphragm.

It is necessary to consider the symptoms arising from the acute and chronic case, and the chronic case which has become acute.

Acute Cases:

When the patient has been severely injured, there are many symptoms and conditions which make it comparatively easy to overlook a tear in the diaphragm, especially when it has been effectively plugged by the stomach, and on examination of the thorax the characteristic signs are absent or difficult to recognize.

It is then important to decide if a perforation of the abdominal viscera, an acute hemorrhage or an incarceration of the intestine exists, with a rupture of the diaphragm.

Chronic Cases:

Atypical and vague gastro-intestinal symptoms in the left hypochondrium, often associated with indefinite pleuritic pain, and a history of injury to the upper abdomen and lower chest, should demand a critical study by a roentgenologist.

Peritoneoscopic examination might be considered in making a diagnosis in obscure chronic cases with indefinite thoracic and abdominal symptoms.

Chronic Cases Which Have Become Acute:

The most common symptom is the sudden onset of severe colicky pain in the hypochondriac region, which is often referred to the neck, shoulder region and anterior lower chest, followed by nausea and persistent vomiting with a disturbance of bowel movements.

The characteristic symptoms of abdominal viscera in the pleural cavity may be absent.

A flat plate of the abdomen and lower chest will often aid in making a diagnosis of incarceration of intestinal viscera in a tear of the diaphragm.

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* Read before the General Surgery Section of the California Medical Association at the sixty-seventh annual session, Pasadena, May 9–12, 1938.

† Only two case reports appear in this issue. Others will be given in the reprints.

PHYSICAL FINDINGS OF THE CHEST

Inspection:

There may be no laceration, contusion, subcutaneous emphysema or evidence of injury to the chest wall or upper abdomen.

The prominence of the chest findings depends upon the kind, amount, distribution and detention of the abdominal viscera, and the rapidity with which they entered the pleural cavity after the tear in the diaphragm, and if a complete pneumothorax resulting from the injury to the lung exists.

Therefore, it is obvious that in some patients dyspnea and cyanosis, with shallow respiration and a lagging of one side of the chest, are the outstanding symptoms, while in others these are absent.

A bulging of the hypochondriac region may be present.

The abdomen is usually scaphoid and often less prominent.

Palpation:

Subcutaneous emphysema, a hematoma and crepitation over the fractured ribs may be elicited. The apex of the heart is usually displaced to the right. Abnormal fremitus is often present. The abdominal muscles are usually rigid.

Percussion:

Normal resonance is displaced by tympany over the anterior chest and the degree of dulness, posteriorly, depends upon the amount of fluid present and the extent of atelectasis.

The tympanic sounds may be caused by a pneumothorax, and cannot be differentiated by percussion from abdominal viscera in the pleural cavity.

Auscultation:

The heart sounds are distant and displaced to the right. Normal breath sounds are decreased or absent, depending upon the amount and distention of the abdominal viscera in the pleural cavity and the presence of a pneumothorax.

Hearing peristaltic contraction over the chest is pathognomonic of intestinal organs in the pleural cavity. The shifting of the patient and listening for many minutes may be necessary before peristalsis is heard.

Gurgling is readily demonstrated over the anterior chest, in the fourth or fifth interspace, by having the patient take liquids in a sitting position.

This auscultatory finding can be accentuated by the administration of an effervescent powder. The application of the powder may be of value during a fluoroscopic examination when a pneumothorax exists, with a ruptured diaphragm.

Any gurgling, splashing or rumbling sound in the chest should be carefully investigated.

The routine fluoroscopic and x-ray examination will often fail to detect a rupture of the diaphragm.

DIAGNOSIS

Kirkin [1] states that the chief obstacle to the diagnosis of a diaphragmatic hernia is the neglect to look for it.

It is often extremely difficult to make an early diagnosis of traumatic diaphragmatic hernia because of the severe concomitant injuries and the bizarre, vague chest and abdominal symptoms. It is my impression that in many cases when the tear in the diaphragm is small, the fundus of the stomach plugs the opening immediately after the injury and prevents the early thoracic symptoms. Later the stomach, along with other movable viscera, may be drawn into the chest, producing the characteristic thoracic symptoms.

A critical study of all such injured persons should be made.

TREATMENT

Keen and experienced judgment is required to decide whether or not to operate upon an acute diaphragmatic rupture when a diagnosis has been made shortly after the injury. In serious injuries to the abdomen, a perforation of the hollow viscus, hemorrhage or incarceration, must always be considered. After observation over a period of hours, if the clinical picture suggests a possibility of any serious intra-abdominal lesion, an exploratory laparotomy should be done. If the patient is in an extremely serious condition, it might be advisable only to control the hemorrhage, repair the perforated viscus or relieve the incarceration, but not repair the rent in the diaphragm. The additional surgery may be too much for the patient to tolerate, but he can survive with a tear in his diaphragm, which can be repaired at a later date.

If intra-abdominal injury can be excluded, it is advisable to institute conservative treatment until such time as the patient is a good operative risk. However, the earlier surgery can be done the less difficulty will be encountered. Chronic cases which become acute should be operated upon at once, by the abdominal route. A supraclavicular temporary phrenic interruption is optional immediately before the laparotomy; nasal gastric lavage should always be done prior to surgery, leaving the tube in the stomach during and after surgery.

In chronic cases, transpleural approach offers many advantages over the abdominal route:

1. Adequate exposure is readily obtained.
2. The phrenic nerve may be crushed or injected with novocain as it enters the diaphragm, which insures an early return of function. After the hernial opening is exposed, it may not be advisable to interrupt the phrenic nerve, where in the abdominal method this must be done before surgery. This is an advantage.
3. Adhesions of the abdominal viscera to the lung or chest wall can be severed by sharp dissection under direct vision.
4. The atelectatic lung can be properly reexpanded by positive pressure under direct vision.
5. If necessary, a fascia lata transplant with living fascial sutures can easily be done, with a decrease in circumference of the chest by multiple rib resection, if necessary.

When difficulty is encountered, by either the abdominal or transpleural approach, it is advisable to combine both methods. The operator should be familiar with each method, and the anesthetist capable of giving positive pressure anesthesia.

PREOPERATIVE TREATMENT IN CHRONIC CASES

In the chronic case it is advisable to give the patient a nonresidual diet of high caloric value, with

an adequate amount of liquids for the dehydrated patient.

A blood transfusion should be given when the patient is anemic or has a low blood pressure. The evening before the operation a thorough gastric lavage should be done, to be repeated before going to surgery, leaving the intranasal Levine tube in the stomach. When a distended transverse colon is in the pleural cavity, a high rectal tube should be inserted.

ANESTHETIC

Avertin, 70 to 90 minims per kilo body weight, supplemented with nitrous oxid and oxygen, under 10 to 14 millimeters of mercury with positive pressure, was satisfactorily used in three cases. In one case—that of a twelve-year-old boy—only nitrous oxid was used, with good results. In one case it was thought advisable to use ethylene. In three cases, cyclopropane, given by the intratracheal method, was used to an advantage. The operative procedure is made less difficult with this type of an anesthetic.

I have come to the conclusion, in reference to anesthesia, that the most important factor is not the kind of anesthetic agent and mode of administration, but the anesthetist giving the anesthetic.

TECHNIQUE OF THE TRANSPLEURAL OPERATION

The patient is placed on the operating table on his good side, resting on a sand bag or folded blanket under the midaxillary portion of his chest.

The incision begins just lateral to the costal attachment of the ribs in the eighth interspace, and continues backward, parallel to the ribs to their angles. The pleural cavity is opened the entire length of the incision.

Upon opening the pleural cavity, in chronic cases, few changes take place in the patient's general condition because the mediastinum has been stabilized and the structures have compensated for the altered conditions within the affected pleural cavity.

To enlarge the opening in the pleural cavity, the eighth and ninth ribs are cut between two punched holes about two centimeters apart, just lateral to the angle of the ribs. After protecting the wound edges with gauze pads, self-retaining retractors are inserted at the upper and lower angles of the incision, and the wound is widely separated.

If, on exploration, the colon is markedly dilated and more than the usual amount of difficulty is encountered in deflating the colon, the possibility of a growth in the distal portion of the colon should be considered; and, if found, a cecostomy with immediate decompression technique is advisable.

The stomach should be examined for pyloric stenosis, ulcer, malignancy, and a volvulus. I failed to recognize the volvulus in the first case, necessitating an abdominal operation for its correction. This condition could have been easily repaired at the first operation, if it had been recognized.

The phrenic nerve is readily seen at its entrance into the diaphragm and easily crushed with a forceps, producing a temporary paralysis of the diaphragm, which facilitates the reduction of the abdominal viscera and the repair of the hernial opening.

The phrenic interruption may not be necessary in all cases. The adherent abdominal viscera are separated from their attachment to the lung and inner chest wall by sharp dissection. Structures are always adherent to the margins of the hernial opening; these are loosened, and if necessary the opening in the diaphragm enlarged, which makes the reduction of the abdominal viscera easier and allows for an exploration below the diaphragm, which should be done in all cases.

After the edges of the diaphragm have been denuded, they are approximated, without tension, with interrupted black silk sutures. If the defect in the diaphragm cannot be closed without tension, a fascia lata transplant, using fascial sutures, can readily be used to fill the defect.

In the eight cases it was interesting to note the gradual expansion of the atelectatic lung after the abdominal viscera had been replaced. In the one case where the accident had occurred ten years previously, the atelectatic lung was gradually but completely reëxpanded by an increase of positive pressure through the tracheal catheter.

Before closure of the pleural cavity the sectioned ribs are approximated with kangaroo tendon. The opening in the pleural cavity is closed by placing interrupted No. 1 chromic sutures around the ribs, above and below the intercostal opening. The muscles and fascia are approximated in their anatomical planes with No. 1 chromic sutures. The pleural cavity is not drained.

POSTOPERATIVE TREATMENT

No unusual postoperative treatment is necessary, excepting that the intranasal Levine tube should be left in the stomach and connected with a constant suction apparatus for forty-eight to seventy-two hours, to prevent a gastric dilatation.

If only a small amount of fluid collects in the pleural cavity, it should not be aspirated.

CONCLUSIONS

Eight cases of traumatic diaphragmatic hernia have been reported, seven males and one female, ranging in age from twelve to fifty-seven years, in which four early and four late diagnoses were made, varying from a few months to ten years.

Earlier diagnoses will be made when the physicians become familiar with the symptoms resulting from a diaphragmatic hernia, and the roentgenologist makes a critical study of cases receiving direct and indirect injuries to the lower chest and upper abdomen, where vague and not clearly explainable thoracic and abdominal symptoms exist.

The earlier the patient can be operated, consistent with safety, the better.

If it is necessary to explore the abdomen shortly after an injury, and a diaphragmatic tear is found but effectively plugged by the stomach, it is advisable to do the urgent surgery and leave the repair of the diaphragm for a second operation.

The transpleural repair after a temporary phrenic interruption, using intratracheal cyclopropane anesthesia under positive pressure, is the method of choice in operating upon the chronic case of traumatic rupture of the diaphragm.

REPORT OF CASES

CASE 1.—Mexican, age 30, injured in an automobile accident on May 10, 1935. Admitted to hospital in a comatose condition, suffering from cerebral concussion, acute alcoholism, and left lower chest injury.

Roentgenograms on May 11 revealed a fracture of the tenth and eleventh ribs posteriorly, without material displacement. No unusual findings in the chest. A small comminuted fracture of the left iliac bone was noted. The patient was discharged from the hospital on May 18, 1935. Because of gastro-intestinal symptoms which were present since the accident, he was given an appointment in the medical out-patient clinc.

He reported to the clinic on May 22, 1935, complaining of diffuse epigastric colicky pain, dyspnea upon exertion, and a nonproductive cough. These symptoms had developed since the accident. A hyper-resonance with decreased breath sounds, and a few crepitant râles at the apex were noted, and a tentative diagnosis of pulmonary tuberculosis was made.

Roentgenograms on May 23 showed a partial pneumothorax, involving the lower left lobe of the lung with a fluid level extending to the sixth interspace anteriorly.

On June 22, 1935, on fluoroscopic examination it was noted that the fluid had disappeared and a high, not well-defined diaphragm, with a deformity of the left dome, aroused suspicion, and upon the administration of barium, the cardiac end of the stomach was seen at the level of the seventh rib posteriorly. A diagnosis by the roentgenologist, of traumatic rupture of the diaphragm, was suggested. On September 15, 1935, he was readmitted to the hospital, complaining of distress in the epigastrium, nausea after eating, and dyspnea upon exertion, since the accident in May, 1935. The barium meal and barium enema revealed that the stomach and colon were in the left chest. A transpleural approach was made through the eighth interspace, under ethylene anesthesia and positive pressure. The entire stomach, transverse colon, spleen, and a portion of the small intestine were in the left pleural cavity. The lower lobe of the lung was atelectatic.

The rent in the diaphragm was about 16 centimeters long, extending obliquely backward from the anterolateral attachment of the diaphragm over its dome to the esophageal hiatus. After crushing the phrenic nerve the viscera were dissected from the margins of the tear in the diaphragm and the abdominal structures replaced into the abdomen and the rent repaired with interrupted silk sutures.

The intercostal wound was closed by placing chromic sutures around the rib above and below the incision, with a continuous chromic suture for the muscle and fascia. Convalescence was delayed by wound infection and a small empyema which healed after adequate drainage was established.

Three months after surgery the patient complained of epigastric distress after meals. He stated that he felt a fullness under his left ribs after eating and that, by bending over and massaging the upper left abdomen, he could feel the food pass into the lower portion of the stomach.

Roentgenological examination with a barium meal revealed a ruminating type of stomach. His condition did not improve with medication and dietetic management. The abdomen was opened through a left rectus incision. A short dense band of adhesions was found, extending from the greater curvature of the stomach at its upper third, to the posterior portion of the scar in the diaphragm, rotating the upper portion of the stomach on itself. After severing this band the stomach assumed a normal position. The previous rent in the diaphragm was visible and firmly healed. Upon subsequent examination the patient was in excellent health and free of complaints.

The second operation could have been obviated if a more thorough examination had been made during the first operation.

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CASE 2.—Male, age 30. On October 19, 1931, was in an automobile accident, receiving injuries to the head, left chest, and lower back.

Roentgenograms on October 20, 1931, disclosed a fracture of the seventh rib in midaxillary line, with no material displacement; a fracture of the superior and inferior rami of the left pubic bone; fracture of the left acetabulum, with some inward displacement; fracture of the first and second sacral segment on the left side. No abnormal findings in the chest. Discharged from hospital on December 29, 1931.

At intervals, from January 7 to October 27, 1932, the patient was seen in the orthopedic clinic. No reference to chest.

In April, 1935, he fell off the running board of a car, striking his head. He was dizzy, with blurred vision and headaches. Diagnosis: Concussion. X-ray examination showed no skull fracture.

On October, 1935, chest was examined; impaired resonance in left apex with fine râles present. Diagnosis was made of pulmonary tuberculosis early, and he was sent to the tuberculosis clinic.

X-ray of October 3, 1935, showed hydropneumothorax, with fluid level at eighth interspace near posterior axillary line. Slight collapse of left lung; evidence of thickened pleura in interlobar fissure.

On July 29, 1936, x-ray showed diaphragm level third interspace, anterior. Stomach lies immediately under diaphragm medially and anteriorly. Diaphragm is terraced from anterior to posterior, so that it is at eighth rib anterior. There are loops of small intestine laterally and posteriorly to the stomach and beneath the diaphragm. The barium entered the stomach readily and emptied into the duodenum normally. The left diaphragm was slightly movable. The findings were consistent with those of a diaphragmatic hernia.

On August 5, 1936, the patient was operated upon by the transpleural approach. On opening the pleural cavity the entire stomach, transverse colon, about 20 centimeters of small intestine, and the spleen were in the pleural cavity. The lower lobe of the lung was atelectatic.

The tear in the diaphragm began at its anterolateral attachment and extended backward toward the esophageal hiatus. The tear was repaired with interrupted silk after the abdominal viscera were replaced into the abdomen.

A pleural effusion occurred postoperatively, and was gradually absorbed without any complications.

On October 13, 1936, the x-ray showed the stomach in normal position, below the diaphragm.

1005 Brockman Building.

REFERENCE

1. Kirklin: J. A. M. A. (Dec. 27), 1930.

DISCUSSION

CHARLES EATON PHILLIPS, M. D. (2007 Wilshire Boulevard, Los Angeles).—Doctor Schiffbauer has given us a comprehensive treatise on the transthoracic repair of diaphragmatic hernia. But there are a few points in the surgical treatment of diaphragmatic hernia which should be accentuated.

First: The diagnosis of diaphragmatic hernia may offer many difficulties. A majority of the cases are not recognized until the condition has become well developed. Many are not found or even suspected until they are found at autopsy. Diaphragmatic hernia, like others, develop in points of congenital weakness, except those which follow direct traumatism such as from drainage tubes, wounds of the diaphragm, etc. A great majority are well developed when some sudden strain brings on an acute exaccerbation, and this leads to their discovery.

Even the exploratory operation may fail to reveal its presence unless there is x-ray evidence to guide the examination.

The mere presence of a diaphragmatic hernia is consistent with a normal span of life and activity.

It becomes a surgical emergency only in the rare cases where it is complicated by acute displacement of the stomach or other viscera, and possible strangulation.

The surgical relief of the condition has had the advocates who favored the abdominal, and others who have preferred the transthoracic approach. Each has had its technical difficulties and its advantages. Both approaches are formidable procedures which require skill and special instruments in their performance.

For the past ten years I have employed an approach which has presented certain advantages over either the classic thoracic or abdominal incisions.

Operation: A left paramedian incision is made, severing the seventh costal cartilage and extending downward to the level of the umbilicus. A careful exploratory is then performed. From the upper end of this incision the open-

ing is continued outward and downward along the attachment of the diaphragm for a distance of eight inches. This flap is then turned outward and downward, leaving a triangular opening with the diaphragm edge presenting. It gives ready access to both sides of the diaphragm and at the same time perfect exposure to the structures, such as the splenic pedicle and vessels which may be injured in either of the other approaches.

Separation of adherent viscera and ligation of all bleeding points, and replacement of viscera, can be accomplished with certainty. Closure of the defect is simple and is usually accomplished with two or three rows of a forty-day chromic gut.

After the diaphragm has been repaired the costochondral flap is replaced and the cut edge of the diaphragm is included in the running chromic stitch which closes the lateral prolongation of the incision.

The paramedian incision is then closed in the same manner, completing the operation. Even in difficult cases the time of operation should not take more than thirty minutes. No subsequent trouble has been encountered with the fracture of the costochondral flap. No special instruments are necessary.

In the presence of adherent viscera it furnishes the ideal approach.

Many cases are not surgical. Surgery may be contraindicated by age, physical condition, or personal preference. In these, great relief may sometimes be obtained by increasing the intrathoracic pressure. These patients may develop a certain emphysema by blowing rubber balloons two or three times a day. The improvement, following this simple procedure, has been startling in some cases.

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EMILE HOLMAN, M. D. (Stanford University Hospital, San Francisco).—Doctor Schiffbauer has very ably and very completely covered the subject of diaphragmatic hernia due to trauma. Physicians generally, and industrial and traumatic surgeons in particular, will do well to bear in mind the possibility of such a hernia incident to any severe trauma to abdomen or to chest. If a diagnosis of hernia through the diaphragm is made, and if abdominal symptoms predominate, the abdominal approach is indicated, preferably through a long incision parallel to the costal margin extending through the linea alba medially and to the anterior axillary line laterally. An excellent exposure of the diaphragm is obtained, and after reduction of the hernial mass it is sometimes possible to identify and crush the phrenic nerve through the rent, if this is deemed necessary to approximate the edges of the rent.

Occasionally, in the abdominal approach, it is difficult to withdraw the abdominal viscera through the rent because of the negative pressure in the thoracic cavity. This can be simply overcome by the passage of a small catheter through the rent alongside the herniated mass, and by the introduction through it of air into the thoracic cavity above the diaphragm, thus equalizing the pressures in the two cavities.

VITAMIN-DEFICIENCY STATES: THEIR RECOGNITION AND TREATMENT*

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PART I

THE concept that disease may be due to deficiency of vitamins has received such widespread proof, and has been so universally accepted, that our clinical interest must now turn to means of recognizing and treating vitamin-deficiency states as well as to a study of the events leading to development of them. The importance of establishing these points lies principally in the fact that vitamin-deficiency states are an unusual group of diseases in that they can be entirely prevented and that, with the exception of a few extreme instances, they are completely amenable to cure.

* Read before the Pediatric Section of the California Medical Association at the sixty-seventh annual session, Pasadena, May 9–12, 1938.

CHARACTER OF DEFICIENCY STATES

For purposes of a clearer understanding of deficiency diseases and the difficulties surrounding recognition of them, such a simple grouping as that presented in Table 1 is of considerable value. In the first group are those patients who, with a marked degree of deficiency, present a classical deficiency disease, as xerophthalmia, beriberi, or pellagra. Such a condition depends on definite pathologic changes in the tissues, it can be recognized by clinical means without recourse to special tests, and it is infrequently encountered in this country.

In a second group may be placed those diseases which are usually due to a moderate degree of deficiency, such as the multiple neuritis of chronic alcoholism, nutritional night blindness, certain types of macrocytic anemia and glossitis. In these cases the deficiency is less marked than in the cases of the preceding group, the symptoms depend on physiologic and pathologic changes, and the diagnosis may rely on the use of special diagnostic tests.

In many respects the sequence of events in these two groups of "deficiency states" may be likened to those occurring in patients with diabetes, nephritis or cardiac disease. Patients with a marked degree of vitamin deficiency may be said to be analogous to diabetic or nephritic patients who are in coma, or to cardiac patients who are decompensated and in whom the pathologic changes are extensive and the diagnosis may be made by clinical means alone. Patients with less marked degrees of deficiency, in whom the pathologic changes are less obvious but the physiologic ones very definite, may be considered analogous to patients with definite diabetes, nephritis or heart disease, in whom the symptoms may depend as much on physiologic as on pathologic changes, and in which special tests may or may not be required before a diagnosis can be established. The frequency with which deficiency disease of moderate degree occurs has not been clearly established, but these conditions are apparently common enough to be encountered by most physicians at fairly regular intervals, and to constitute at present the usual case of vitamin deficiency disease.

In a third group may be placed those conditions in which the deficiency is mild and in which recognition of the deficiency may be said principally to depend upon physiologic or chemical alterations rather than on pathologic ones. In fact, recognition of this group of cases in which clinical changes are often absent has depended on the development of special tests, such as the biophotometric determination of dark adaption of the eyes in vitamin A deficiency and the chemical measurement of the saturation of the tissues with vitamin C. The clinical significance of this group of "deficiency states" has not been settled. To carry further the previously mentioned analogy, one might say that this group corresponds to those diabetics in which the diagnosis can be made only after careful studies of the tolerance to dextrose, or with those nephritics who do not present clinical signs of renal